



INDIANA
DEPARTMENT *of*
EDUCATION

2023 INDIANA ACADEMIC STANDARDS **SCIENCE**

INTEGRATED CHEMISTRY & PHYSICS



Indiana Academic Standards Context and Purpose

Introduction

The Indiana Academic Standards for Integrated Chemistry and Physics are the result of a process designed to identify, evaluate, synthesize, and create high-quality, rigorous learning expectations for Indiana students.

Pursuant to Indiana Code (IC) 20-31-3-1(c-d), the Indiana Department of Education (IDOE) facilitated the prioritization of the Indiana Academic Standards. All standards are required to be taught. Standards identified as essential for mastery by the end of the course are indicated with the word “Essential” under the standard number.

The Indiana Academic Standards are designed to ensure that all Indiana students, upon graduation, are prepared with essential knowledge and skills needed to access employment, enrollment, or enlistment leading to service.

What are the Indiana Academic Standards and how should they be used?

The Indiana Academic Standards for Grades K-12 Science are based on *A Framework for K-12 Science Education* (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013). The following conceptual shifts reflect what is new about these science standards. The Indiana Academic Standards for Science:

- Reflect science as it is practiced and experienced in the real world;
- Build logically from kindergarten through grade 12;
- Focus on deeper understanding as well as application of content; and
- Integrate practices, crosscutting concepts, and core ideas.

The K-12 Science Indiana Academic Standards outline the knowledge, science, and engineering practices that all students should learn by the end of high school. The standards are three-dimensional because each student performance expectation engages students at the nexus of the following three dimensions:

- **Dimension 1** describes scientific and engineering practices.
- **Dimension 2** describes crosscutting concepts, overarching science concepts that apply across science disciplines.
- **Dimension 3** describes core ideas in the science disciplines.

Science and Engineering Practices (as found in NGSS)

The eight practices describe what scientists use to investigate and build models and theories of the world around them or that engineers use as they build and design systems. The practices are essential for all students to learn and are as follows:

1. Asking questions (for science) and defining problems (for engineering);
2. Developing and using models;

3. Planning and carrying out investigations;
4. Analyzing and interpreting data;
5. Using mathematics and computational thinking;
6. Constructing explanations for science and designing solutions for engineering;
7. Engaging in argument from evidence; and
8. Obtaining, evaluating, and communicating information.

Crosscutting Concepts (*as found in NGSS*)

The seven crosscutting concepts bridge disciplinary boundaries and unit core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the disciplinary core ideas, and develop a coherent, and scientifically based view of the world. The seven crosscutting concepts are as follows:

1. *Patterns*. Observed patterns of forms and events guide organization and classification, and prompt questions about relationships and the factors that influence them.
2. *Cause and Effect: Mechanism and Explanation*. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, Proportion, and Quantity*. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and System Models*. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and Matter: Flows, Cycles, and Conservation*. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and Function*. The way in which an object or living thing is shaped and its substructure determines many of its properties and functions.
7. *Stability and Change*. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Disciplinary Core Ideas (*as found in NGSS*)

The disciplinary core ideas describe the content that occurs at each grade or course. The K-12 Science Indiana Academic Standards focus on a limited number of core ideas in science and engineering both within and across the disciplines and are built on the notion of learning as a developmental progression. The Disciplinary Core Ideas are grouped into the following domains:

- Physical Science (PS)
- Life Science (LS)
- Earth and Space Science (ESS)

- Engineering, Technology and Applications of Science (ETS)

While the Indiana Academic Standards establish key expectations for knowledge and skills and should be used as the basis for curriculum, the standards by themselves do not constitute a curriculum. It is the responsibility of the local school corporation to select and formally adopt curricular tools, including textbooks and any other supplementary materials, that align with Indiana Academic Standards. Additionally, corporation and school leaders should consider the appropriate instructional sequence of the standards as well as the length of time needed to teach each standard. Every standard has a unique place in the continuum of learning, but each standard will not require the same amount of time and attention. A deep understanding of the vertical articulation of the standards will enable educators to make the best instructional decisions. These standards must also be complemented by robust, evidence-based instructional practices to support overall student development. By utilizing strategic and intentional instructional practices, other areas such as STEM and employability skills can be integrated with the content standards.

Acknowledgments

The Indiana Department of Education appreciates the time, dedication, and expertise offered by Indiana's K-12 educators, higher education professors, representatives from business and industry, families, and other stakeholders who contributed to the development of the Indiana Academic Standards. We wish to specially acknowledge the committee members, as well as participants in the public comment period, who dedicated many hours to the review and evaluation of these standards designed to prepare Indiana students for success after graduation.

References

- National Research Council. 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/13165>.
- NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

How to Read the Indiana Academic Standards for K-12 Science

Standard Number	Title
<p>The title for a set of performance expectations is not necessarily unique and may be reused at several different grade levels.</p> <p>Students who demonstrate understanding can:</p> <p>Standard Number Performance Expectation: A statement that combines practices, core ideas, and crosscutting concepts together to describe how students can show what they have learned. [Clarification Statement: A statement that supplies examples or additional clarification to the performance expectation.]</p> <p>Essential</p>	
<p>Science and Engineering Practices</p> <p>Science and Engineering Practices are activities that scientists and engineers engage in to either understand the world or solve the problem.</p> <p>There are 8 practices. These are integrated into each standard. They were previously found at the beginning of each grade level content standard and known as SEPs.</p> <p>Connections to the Nature of Science</p> <p>Connections are listed in either practices or the crosscutting concepts section.</p>	<p>Disciplinary Core Ideas</p> <p>Disciplinary Core Ideas are concepts in science and engineering that have broad importance within and across disciplines as well as relevance in people's lives.</p> <p>To be considered core, the ideas should meet at least two of the following criteria and ideally all four:</p> <ul style="list-style-type: none"> • Have broad importance across multiple sciences or engineering disciplines or be a key organizing concept of a single discipline. • Provide a key tool for understanding or investigating more complex ideas and solving problems. • Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge. • Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. <p>Disciplinary ideas are grouped in four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology, and applications of science.</p> <p>A disciplinary core idea is identified as "(secondary)" when the other featured disciplinary core ideas connect to the science and engineering practices and crosscutting concepts as the main focus of the performance expectation.</p> <p>A boundary statement, where applicable, provides guidance regarding the scope of a performance expectation.</p> <p>Crosscutting Concepts</p> <p>Crosscutting concepts are seven ideas such as Patterns and Cause and Effect, which are not specific to any one discipline but cut across them all.</p> <p>Crosscutting concepts have value because they provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas.</p> <p>Connections to Engineering, Technology and Applications of Science</p> <ul style="list-style-type: none"> • These connections are drawn from either the Disciplinary Core Ideas or Science and Engineering Practices.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP1-1 Matter and its Interactions	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]</p> <p>Essential</p> <p>Reference: NGSS HS-PS1-1</p>	
<p>Science and Engineering Practices</p> <p>SEP.2: Developing and Using Models</p> <p>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).</p> <ul style="list-style-type: none"> Use a model to predict the relationships between systems or between components of a system. 	<p>Disciplinary Core Ideas</p> <p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
	<p>Crosscutting Concepts</p> <p>CC.1: Patterns</p> <ul style="list-style-type: none"> Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP1-2 Matter and its Interactions	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.]</p> <p>Essential</p> <p>Reference: NGSS HS-PS1-2</p>	
<p>Science and Engineering Practices</p> <p>SEP.6: Constructing Explanations and Designing Solutions</p> <p>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.</p> <ul style="list-style-type: none"> Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. 	<p>Disciplinary Core Ideas</p> <p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
	<p>Crosscutting Concepts</p> <p>CC.1: Patterns</p> <ul style="list-style-type: none"> Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP1-3 Matter and its Interactions

Students who demonstrate understanding can:

HS-ICP1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.]

Reference: NGSS HS-PS1-3

Science and Engineering Practices**SEP.3: Planning and Carrying Out Investigations**

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Disciplinary Core Ideas**PS1.A: Structure and Properties of Matter**

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

Crosscutting Concepts**CC.1: Patterns**

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP1-4 Matter and its Interactions	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.]</p> <p>Reference: NGSS HS-PS1-4</p>	
<p>Science and Engineering Practices</p> <p>SEP.2: Developing and Using Models</p> <p>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.</p> <ul style="list-style-type: none"> Develop a model based on evidence to illustrate the relationships between systems or between components of a system. 	<p>Disciplinary Core Ideas</p> <p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
	<p>Crosscutting Concepts</p> <p>CC.5: Energy and Matter</p> <ul style="list-style-type: none"> Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

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HS-ICP1-5 Matter and its Interactions	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP1-5 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]</p> <p>Reference: NGSS HS-PS1-8</p>	
<p>Science and Engineering Practices</p> <p>SEP.2: Developing and Using Models</p> <p>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.</p> <ul style="list-style-type: none"> Develop a model based on evidence to illustrate the relationships between systems or between components of a system. 	<p>Disciplinary Core Ideas</p> <p>PS1.C: Nuclear Processes</p> <ul style="list-style-type: none"> Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.
	<p>Crosscutting Concepts</p> <p>CC.5: Energy and Matter</p> <ul style="list-style-type: none"> In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

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HS-ICP2-1 Forces	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.]</p> <p>Essential</p> <p>Reference: NGSS HS-PS2-1</p>	
<p>Science and Engineering Practices</p> <p>SEP.4: Analyzing and Interpreting Data</p> <p>Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.</p> <ul style="list-style-type: none"> Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. <p>-----</p> <p>Connections to Nature of Science</p> <p>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</p> <ul style="list-style-type: none"> Theories and laws provide explanations in science. Laws are statements or descriptions of the relationships among observable phenomena. 	<p>Disciplinary Core Ideas</p> <p>PS2.A: Forces and Motion</p> <ul style="list-style-type: none"> Newton's second law accurately predicts changes in the motion of macroscopic objects. <p>Crosscutting Concepts</p> <p>CC.2: Cause and Effect</p> <ul style="list-style-type: none"> Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP3-1 Energy

Students who demonstrate understanding can:

HS-ICP3-1 Quantitatively analyze various scenarios to describe how the change of energy in one component in a system responds to the change in energy of the other components and flow of energy into and out of the system are known.

Science and Engineering Practices**SEP.5: Using Mathematics and Computational Thinking**

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials, and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Create a computational model or simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas**PS3.A: Definitions of Energy**

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.

Crosscutting Concepts**CC.4: Systems and System Models**

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Connections to Nature of Science**Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

- Science assumes the universe is a vast single system in which basic laws are consistent.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP3-2 Energy

Students who demonstrate understanding can:

HS-ICP3-2 **Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles objects).**

Essential

[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

Reference: NGSS HS-PS3-2

Science and Engineering Practices

SEP.2: Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
- These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Crosscutting Concepts

CC.5: Energy and Matter

- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP3-3 Energy	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.]</p> <p>Reference: NGSS HS-PS3-3</p>	
<p>Science and Engineering Practices</p> <p>SEP.6: Constructing Explanations and Designing Solutions</p> <p>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.</p> <ul style="list-style-type: none"> Design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. 	<p>Disciplinary Core Ideas</p> <p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. <p>PS3.D: Energy in Chemical Processes</p> <ul style="list-style-type: none"> Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment. <p>ETS1.A: Defining and Delimiting an Engineering Problem</p> <ul style="list-style-type: none"> Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (<i>secondary</i>)
	<p>Crosscutting Concepts</p> <p>CC.5: Energy and Matter</p> <ul style="list-style-type: none"> Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. <p>-----</p> <p>Connections to Engineering, Technology, and Applications of Science</p> <p>Influence of Science, Engineering and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP3-4 Energy	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP3-4 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.]</p> <p>Reference: NGSS HS-PS3-5</p>	
<p>Science and Engineering Practices</p> <p>SEP.2: Developing and Using Models</p> <p>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).</p> <ul style="list-style-type: none"> Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. 	<p>Disciplinary Core Ideas</p> <p>PS3.C: Relationship Between Energy and Forces</p> <ul style="list-style-type: none"> When two objects interacting through a field change relative position, the energy stored in the field is changed.
	<p>Crosscutting Concepts</p> <p>CC.2: Cause and Effect</p> <ul style="list-style-type: none"> Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP3-5 Energy	
<p>Students who demonstrate understanding can:</p> <p>HS-ICP3-5 Gather data to build a model to describe and explain the flow of current through series and parallel electric circuits.</p>	
<div>Science and Engineering Practices</div> <p>SEP.2: Developing and Using Models</p> <p>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).</p> <ul style="list-style-type: none"> Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. 	<div>Disciplinary Core Ideas</div> <p>PS3.B: Conservation of Energy and Energy Transfer</p> <ul style="list-style-type: none"> Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. The availability of energy limits what can occur in any system.
	<div>Crosscutting Concepts</div> <p>CC.5: Energy and Matter</p> <ul style="list-style-type: none"> Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. <p>-----</p> <p><i>Connections to Engineering, Technology, and Applications of Science</i></p> <p>Influence of Science, Engineering and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.

HS-ICP4-1 Waves and their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

HS-ICP4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.]

Reference: NGSS HS-PS4-1

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

SEP.5: Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials, and logarithms; and computational tools for statistical analysis to analyze, represent and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas

PS4.A: Wave Properties

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.

Crosscutting Concepts

CC.2: Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Note: Performance Expectations, Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts appear as defined in the Next Generation Science Standards.